Revised Manuscript

FIDDLER ON THE ROOF: A NORTHERN RANGE EXTENSION FOR THE MARSH FIDDLER CRAB *UCA PUGNAX*

David Samuel Johnson

7 MBL Street, Marine Biological Laboratory, Woods Hole, MA 02543, USA

Email: manayunkia@gmail.com

ABSTRACT

A northern range extension is presented here for the marsh fiddler crab *Uca pugnax* (Smith, 1870). In summer 2014, adult crabs were found as far north as Hampton, New Hampshire (42° 55' 27" N, 70° 49' 13" W), which is 80 km north of its previously established northern limit determined in 2003. Thus, the mean annual northern movement of *U. pugnax* is currently 7.2 km y^{-1}. I hypothesize that crabs recruited to the most northern sites during 2012 or 2013 when ocean temperatures were up to 1.3 C higher than the average of the previous decade. In a scenario of continued warming oceans associated with climate change, the range of *U. pugnax* is thus predicted to continue to extend northward. Given that fiddler crabs are ecosystem engineers

affecting coastal wetland productivity, biogeochemistry and sediment structure, the introduction of this species into northern salt marshes may have consequences for marsh structure and function.

KEY WORDS: climate velocity, decapod, marine invasion, *Uca*

DOI:

INTRODUCTION

Uca pugnax (Smith, 1870) is a fiddler crab (Decapoda: Ocypodidae, Fig. 1) found in salt marshes along the east coast of the United States (Grimes et al., 1989). The historic distribution of *U. pugnax* was established as ranging from northern Florida to Cape Cod, Massachusetts (Grimes et al., 1989). In 2003, Sanford et al. (2006) extended the northern limit to Scituate, Massachusetts, 60 km north of Cape Cod. In May 2014 I found a male *U. pugnax* in the Plum Island marshes (Rowley, Massachusetts) during another sampling event. After this observation, I conducted surveys of marshes north and south of Plum Island marshes to determine the extent of the range.

[Fig. 1]

The purpose of this paper is to record an extension of the range of *U. pugnax*. Given the increasing prevalence of organismal range shifts and expansions due to climate change (Perry et al., 2005; Lucey and Nye, 2010; Cheung et al., 2013), including on the east coast of the United

States (Lucey and Nye, 2010; Pinsky et al., 2013), I also examined the possibility of warming ocean temperatures as a driver of this northern extension.

MATERIALS AND METHODS

To establish a range extension for *U. pugnax* I surveyed 17 marshes from the previous northern limit of North Scituate, Massachusetts to Freeport, Maine from 26 June-11 July 2014 (Table 1). I also surveyed 3 marshes that Sanford et al. (2006) had listed as previously devoid of *U. pugnax* in 2003. Surveys consisted of observers walking up to 500 m of tidal creek and marsh ditch lengths at low tide. Once the presence of *U. pugnax* was confirmed (after finding at least two individuals, one of which was male), the search was ended. *Uca pugnax* is an air breathing decapod that typically lives just below mean high water; its burrows were identified as 2-cm round holes [green crab, *Carcinus maenas* (Linnaeus, 1758) and soft-shell clam, *Mya arenaria* burrows are oblong] near or within the vegetation (*Spartina alterniflora* and *S. patens*) with 1-2 mm cylindrical fecal pellets at the burrow entrance. Burrows were most easily seen in unvegetated areas and when found in these areas, adjacent vegetated areas were also searched since *U. pugnax* is found in a variety of marsh habitats (Luk and Zajac, 2013). Crabs were excavated to confirm their presence in a particular marsh. Individual males (the sex used for species identification) were collected and brought back to the lab for identification under a dissecting scope. Where crabs were found, notes about habitat type and burrow density were taken.

To determine if water temperature may be a possible driver of a *U. pugnax* range expansion, I examined near-surface (1-m depth) ocean temperature data from 2001-2013 in

Massachusetts Bay (Station 44029, Buoy A01) and the Central Maine Shelf (Station 44032, Buoy E01). Data courtesy of the Northeast Regional Association of Coastal and Ocean Observing Systems (www.neracoos.org).

RESULTS

Uca pugnax was not found north of Hampton, New Hampshire (42° 55' 27" N, 70° 49' 13" W) (Table 1). Crabs were found in all marshes searched south of Hampton, New Hampshire, including three marshes that were absent of crabs in 2003 (Danvers, Gloucester and Manchester-by-the-Sea, Massachusetts; Sanford et al., 2006). Crabs were rarely found in the vegetation. Crabs were most often found on the-almost vertical faces of creek banks and mosquito ditches and on horizontal benches denuded of vegetation (areas of turf scalping or ice scour).

[Table 1]

Both males and female crabs were found at most sites, including ovigerous females at two sites (Gloucester and Rowley, Massachusetts). Adult carapace width ranged from 1.2 to 1.8 cm. Juveniles (up to 5 mm carapace width) were found in three marshes, North Scituate, Gloucester, and Rowley, Massachusetts.

Based on yearly averages, water temperatures in Massachusetts Bay were 1.3 ºC higher in 2012 and 0.7 ºC higher in 2013 than the mean of 2001-2013 water temperatures combined (Fig. 2). Of particular note are the higher-than-average summer temperatures in 2012 and 2013, a time of larval dispersal and recruitment for *U. pugnax* (Sanford et al., 2006). A similar water-temperature trend was seen for the central Maine shelf (Buoy E01; data not shown).

[Fig. 2]

DISCUSSION

The 2014 northern range of *U. pugnax* is Hampton, New Hampshire. This represents a northern range extension of 80 km north of its previously established northern limit (Sanford et al., 2006). This provides a mean annual northern movement for this species of 7.2 km y^{-1} since 2003.

Given that many marine taxa track climate velocities (Pinsky et al., 2013), I hypothesize that the increased summer water temperatures of 2012 and 2013 facilitated the northern expansion of this species. Similarly, I have found blue crabs (*C. sapidus*) in the Gulf of Maine, which is north of their historic range and may also be associated with warming waters (Johnson, in press). Given that adult *U. pugnax* are able to overwinter in marshes north of their range by capping their burrows, the northern distribution of *U. pugnax* is set by the thermal tolerances of the planktonic larvae (Sanford et al., 2006). The collection of adult crabs in summer 2014 suggests that larvae recruited in 2012 or 2013 when temperatures were warmer than average. Furthermore, larval release and settlement occur in June-July (Sanford et al., 2006, this study), a time when temperatures were greater than average in 2012 and 2013. It is interesting to note that juvenile crabs (5 mm carapace width) were found in three Massachusetts in late June. There are at least two possible explanations for these juvenile crabs. They recruited late fall of 2013 and overwintered as a juvenile or they recruited in June 2014, suggesting a late spring larval release and settlement.

An alternative hypothesis for the northern range extension is that the larvae of northern crabs have been genetically selected to tolerate colder waters (Dennis and Hellberg, 2010). Sanford et al. (2006), however, found that gene flow between northern populations and southern populations is high enough to swamp out selection for cold-tolerant crabs. Thus, warming oceans is a likely driver of this range expansion.

I would suggest that *U. pugnax* recruited to the most northern sites (Ipswich, Massachusetts and north) in 2012 or 2013. I suggest this with confidence because the Rowley and Ipswich marshes are part of the Plum Island Estuary Long-Term Ecological Research program and benthic invertebrate monitoring has not yielded any fiddler crabs until this year (Johnson et al., 2007; Johnson and Fleeger, 2009,; http://ecosystems.mbl.edu/pie/data.htm). At all sites crab burrow density appeared to be low and quadrat surveys of Rowley and Ipswich, Massachusetts, marshes indicate extremely low densities (< 0.1 m^{-2}, Johnson, unpublished data).

As a burrowing crab, fiddlers are ecosystem engineers that can have significant effects (both positive and negative) on marsh function and structure by influencing plant productivity and recruitment, biogeochemical cycling, soil strength, and carbon storage (Gribsholt et al., 2003; Holdredge et al., 2010; Thomas and Blum, 2010; Smith and Tyrell, 2013). Thus, a continued *U. pugnax* northward movement associated with climate change could signal significant changes in marsh functioning in marshes that previously did not have fiddler crabs, e.g., the Plum Island Estuary.

ACKNOWLEDGEMENTS

I thank Jon Whitcomb, Caitlin Bauer, Kailani Acosta, Oliva Bernard, Ashley Bulseco-McKim, Jimmy Nelson, Imogene Robinson and Bethany Williams for their field assistance. I thank Richard Heard for his always insightful comments. Comments by Frederick Schram improved the manuscript. This work was funded by NSF 1354494 and 1238212.

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RECEIVED: 12 July 2014

ACCEPTED: 16 July 2014

AVAILABLE ONLINE: ???

Table 1: Survey of *Uca pugnax* in salt marshes of the northeast United States in June and July 2014. *Sanford et al. (2006) surveyed these marshes in 2003 and did not find any *U. pugnax*
[‡]The former northern limit of *U. pugnax* established by Sanford et al. (2006).
NERR is the abbreviation of the National Estuarine Research Reserve

Location	Latitude (N), Longitude (W)	*U. pugnax* present?
Freeport, ME Winslow Memorial Park	43° 48' 10", 70° 6' 51"	No
Scarborough, ME Near Eastern Trail in Scarborough Marsh	43° 33' 39", 70° 22' 11"	No
Wells, Maine Wells NERR/ Rachel Carson National Wildlife Refuge	43° 19' 13", 70° 34' 1"	No
Greenland, New Hampshire Great Bay NERR	43° 3' 17", 70° 53' 50"	No
Rye, New Hampshire Rye Harbor State Park	43° 0' 13", 70° 45' 0"	No
North Hampton, New Hampshire North Hampton State Park	42° 57' 27", 70° 46' 49"	No
Hampton, New Hampshire Hampton Salt Marsh Conservation Area	42° 55' 27", 70° 49' 13"	Yes
Salisbury, Massachusetts Salisbury Beach State Reservation	42° 49' 57", 70° 49' 6"	Yes
Newbury, Massachusetts Pine Island Creek	42° 46' 34", 70° 49' 42"	Yes
Rowley, Massachusetts Nelson Island Creek, Parker River National Wildlife Refuge	42° 44' 37", 70° 50' 13"	Yes
Ipswich, Massachusetts Sweeney Creek	42° 43' 16", 70° 50' 51"	Yes
Essex, Massachusetts Eben Creek	42° 38' 7", 70° 45' 47"	Yes
Gloucester, Massachusetts Near 99 Atlantic Street*	42° 38' 14", 70° 42' 4"	Yes
Manchester-by-the-sea, Massachusetts Kettle Cove	42° 34' 41", 70° 44' 7"	Yes

Manchester-by-the-sea, Massachusetts Chubb Point Marshes*	42° 33' 56", 70° 47' 34"	Yes
Danvers, Massachusetts Waters River Marshes*	42° 32' 48", 70° 56' 25"	Yes
North Scituate, Massachusetts Musquashcut Brook‡	42° 13' 35", 70° 46' 26"	Yes

FIGURE CAPTIONS

Fig. 1. A, male *Uca pugnax* from marshes near Chubb Point in Manchester-by-the-Sea, Massachusetts, in June 2014. In 2003, there were no fiddler crabs found at this site (Sanford et al. 2006). Photo: Jon Whitcomb; B, ovigerous female *U. pugnax* in Rowley, Massachusetts, in June 2014. Photo: Ashley Bulseco-McKim.

Fig. 2. Water temperature data 1 m below the surface of Massachusetts Bay (Buoy A01). Solid black line represents monthly mean temperature. Dashed white line represents monthly mean data averaged across years 2001-2013. Gray band represents monthly maximum and minimum temperatures recorded from 2001-2013. Data courtesy of www.neracoos.org

Figure 1A
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Figure 1B
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